(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 April 2002 (18.04.2002)

PCT

(10) International Publication Number
WO 02/30348 A2

(51) International Patent Classification[7]: A61G 13/00

(21) International Application Number: PCT/DK01/00658

(22) International Filing Date: 9 October 2001 (09.10.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 2000 01503 9 October 2000 (09.10.2000) DK

(71) Applicant *(for all designated States except US)*: **BENCA TECHNOLOGY APS** [DK/DK]; Rungsted Havn 1 F, DK-2960 Rungsted (DK).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **DAHLERUP, Benedicte** [DK/DK]; Marievej 23, DK-2960 Vedbæk (DK).

(74) Agents: **NIELSEN, Kim, Garsdal** et al.; Internationalt Patent-Bureau, Høje Taastrup Boulevard 23, DK-2630 Taastrup (DK).

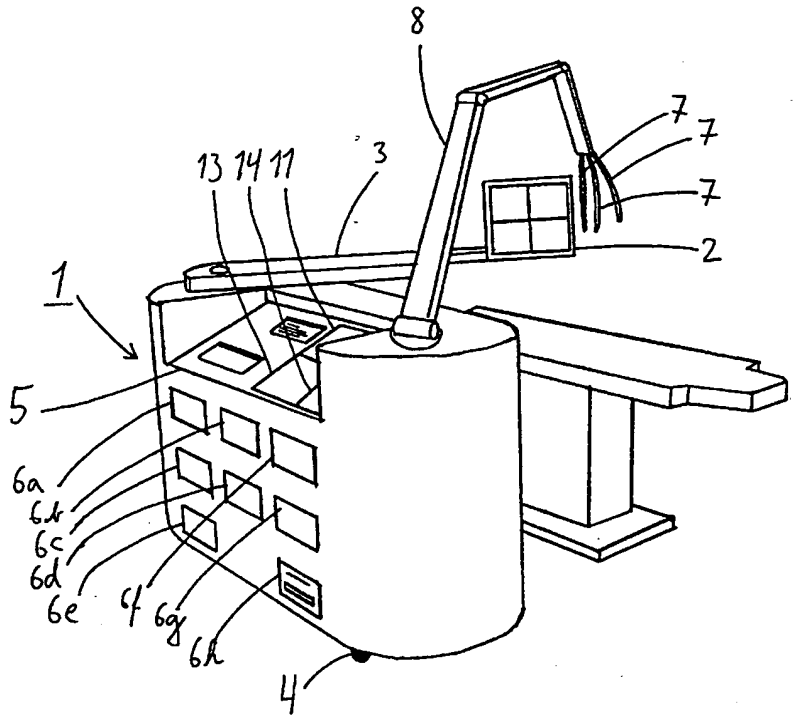
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

[Continued on next page]

(54) Title: A SURGICAL WORKSTATION



(57) Abstract: The invention relates to a mobile surgical workstation comprising a housing adapted for accommodating medical subunits. The surgical workstation is adapted for accommodating exchangeable modular subunits. The invention also relates to an operating room equipped with such a workstation.

WO 02/30348 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A surgical workstation

The present invention relates to a mobile surgical workstation, and an operating room equipped with such a workstation.

The equipment needed to perform a neurosurgical operation, endoscopy, microsurgery or keyhole surgery, is large and cumbersome. In an operating room, it occupies a lot of space and is not always in the best position for easy use, or ergonomic for the surgeon. Traditional equipment involves the use of connecting cables and wires, hanging in the air and lying on the floor, which can be hazardous.

The complaints often heard in the operating room are that there are too many things on the floor, the room is crowded, the warm-up time is too long, and that there are too many different systems, difficult to combine and hard to use. The devices are not self-explanatory and they fail to communicate. There are too many switches, they are located in odd places that are difficult to find, and often the connections do not fit together. Keeping things sterile is troublesome, and there is too much for the nurses to learn about the technical equipment. This results in a few "specialist nurses", who are not always at the hospital when needed. To change from one patient to the next simply takes too long.

What surgeons want today in the operating rooms is: Simplification, central control, room efficacy, integrated operating rooms, alternative viewing systems, upgradable systems, better ergonomics for surgeons and nurses, user-friendly equipment and stardardisation.

In other fields of surgery, attempts have been made to overcome similar problems.

From DE-U1-9218373 there is known a workstation for minimally invasive surgery.

The workstation comprises a mobile case in which various functional units necessary for minimally invasive surgery are accommodated. The workstation further includes an arm on which a control panel and patient connection field are located.

However this workstation has only gained limited popularity, presumably because it is inflexible in the selection of the devices. In particular, the units may only be replaced by corresponding functional units having the same dimension as the original unit. Because of this, only certain specific operations may be performed with this workstation. Moreover, the workstation needs to be placed in very close proximity of the operating table, thus limiting access thereto.

A similar, but substantially less mobile workstation is known from WO-A-99/23989. This workstation also has all units integrated. The flexibility is further reduced by the use of an umbilical mounted to the ceiling in a quite inaccessible fashion.

Another attempt to overcome the above problems is known from EP-A2-876799. In this document is disclosed a two-part workstation wherein the various functional units are located in a case away from the operating table. This case is immobile and located away from the operating table. Because it is located away from the operating table it is necessary to have a cable connection from the case to the operating table. This cable is a large flat cable, which is still quite an inconvenience. In particular such a cable may be inconvenient when the operating room has to be cleaned.

Attempts to conceal the cable using the floor or the ceiling of the operating room are found in e.g. DE-A1-19807241, DE-A1-19807242 and DE-A1-

19807243. Using the floor and/or the ceiling of the operating room is problematic because it requires the existence of an infrastructure adapted for the specific solution. Any limitations in this infrastructure will also limit the mobility of the workstation.

It is the object of the present invention to provide a surgical workstation, which overcomes the above problems in respect of untidiness in the operating room, allows for better cleaning, is highly flexible in use, both in respect of adaptation with units needed for a specific operation, and in respect of the positioning of the workstation in the operating room.

According to the present invention this is achieved by a surgical workstation according to the present invention characterized in that the surgical workstation is adapted for accommodating exchangeable modular subunits.

By providing a surgical workstation which is at the same time both modular and mobile the following advantages are obtained.

The mobile surgical workstation may be easily configured to a specific operation. In particular this configuration need not take place in the operating room, but may take place in another room.

If a hospital has more mobile surgical units at its disposition and more than one of each type of modular subunit, this allows a second surgical workstation to be configured for the next operation to take place in an operating room, during the time when an operation takes place in the operating room using a first workstation.

After the operation, the first workstation may be moved to another place for reconfiguration while the second workstation, configured for the next operation takes its place. This reconfiguration may take place in a different room, but may just as well

take place in the operating room itself. If the first workstation is moved out of the operating room the floor and other parts of the operating room will be readily accessible for cleaning until the time when the second workstation is moved in.

Moreover, because the workstation is fully mobile, it may be used in other places than the actual operating room. In particular, it may be moved to the bed of the patient for smaller surgical operations.

Another advantage is that the work station can be bought nearly empty and then slowly filled up with subunits according to budgets and the use existing materiel, which is not yet invalidated or outdated. Old hospital equipment can be phased out as new subunits are phased in. Leasing can also be an option.

In a preferred embodiment the mobile surgical workstation comprises a central controlling unit and interface means allowing the central controlling unit to communicate with any modular subunit accommodated in the workstation.

This has the advantage that all modular subunits may be controlled by the same user interface.

In a further preferred embodiment the communication between the central controlling unit and the subunit(s) takes place within the housing of the surgical workstation.

This has the benefit that no connections need to be made externally, except the power supply though a mains connection. This makes the operating room more tidy, and allows for easy disconnection and removal of the workstation from the operating room, for cleaning and/or for reconfiguration. The configured workstation thus constitutes a self-contained unit, needing only external power. All other connections, such as e.g. external communication, being optional.

In another preferred embodiment the mobile surgical workstation further comprises an applicator arm

having a first end pivotally and tiltably connected to the workstation, said application arm comprises at a second end the connections or further connections, such as plugs, to medical applicators, said connections being in data communications with medical subunits of the workstation.

This allows those surgical instruments, which need to be connected to the workstation, to be presented and located in an ergonomically convenient or preferred place for the surgeon using the workstation.

In another preferred embodiment the surgical workstation further comprises a central power supply supplying power to subunit(s) of the workstation.

A common power supply is advantageous because the workstation only needs one mains connection. Moreover the internal power supply may take place via an internal standardized bus and device interface.

In yet another preferred embodiment the surgical workstation further comprises at least one monitor configured to display information supplied by one or more subunits of the workstation.

This allows all displays to be combined in one single graphical touch sensitive user interface.

Preferably said monitor(s) being arranged in relation to the workstation in such a manner that the information can be presented in front of a surgeon during operation.

This allows the surgeon to have direct access to the information necessary for the operation. He may then control the units directly via the graphical user interface or separate control means e.g. such as voice control.

In still another preferred embodiment said monitor(s) being high definition video screen(s), divided into sections, preferably divided into four

sections, and wherein the monitor(s) being arranged on a swing arm mounted on the workstation.

This allows the information to be presented directly in front of the surgeon if he so desires, but without hindering his operation.

In another embodiment the workstation is configured to communicate data between medical units of the workstation and data equipment not being included in the workstation, preferably the configuration to communicate data is a data connection between the central controlling unit and a data network, such as a intranet, a internet or the like.

This allows for the data to be displayed elsewhere.

In a specifically preferred embodiment the workstation is mounted on wheels.

Using wheels allow the workstation to be easily manoeuvred around and positioned, be it within the operating room or outside thereof.

The present invention further relates to an operating room comprising a surgical workstation as described above.

In the following preferred embodiments of the present invention will be described in an exemplified manner with reference to the accompanying figures. It should be quite clear to a person skilled in the art that modifications of the preferred embodiments are within the scope of the present invention. In these figures,

Fig. 1 shows a mobile surgical workstation with modular units in accordance with the present invention, located at a distance from an operating table, and

fig. 2 shows the surgical workstation with the modular units drawn out.

The operating room according to the present invention could be compared with a ship's command

bridge, where all the necessary equipment for the voyage is collected into one machine unit, well hidden. There is a display and a keyboard in front of the captain, easy to overview and to use. The Command Bridge does not look like a messy warehouse, as a modern operating room does today.

For these reasons the surgical workstation 1 is designed to combine all necessary components and their functionality into a single, convenient and handy unit, incorporating all the technical instruments, which the surgeon requires to perform an operation.

Modular design has already been established for the anaesthetist's equipment in the operating room and the monitors in the ICU. In general surgery several modular systems are available such as the ISIS and the OREST modular design. Other intelligent systems are also available in surgery, examples are the EndoAlpha Integrated Endosurgical Systems from Olympus, the OR1 from Karl Storz and The Siemens Integrated OR System, SIOS.

As mentioned above one object of the present invention is to change the set-up in operating rooms from chaos to order and to reduce the time-consuming operation planning procedure. Another goal is to encourage surgeons to bring modern technology into use, which will increase accuracy, enhance the field of vision and thereby minimize the surgical procedures. The third goal is to create an expert platform in surgery, using the Internet and teleconference as an integrated tool in teaching, rehearsing and performing.

The Equipment

Electrocautery, irrigation, suction and CO_2 insufflation.

The units are standardized with a unified adapter system. Flexible modules can be individually chosen according to the surgeons's choice of electrocautery unit. The instruments are preferably wire-free and as low-weight as possible. A built-in peristaltic irrigation system will supply a constant, even stream of warm saline water through the endoscopes and coagulation forceps. The suction device is a closed, disposable system. CO_2 insufflation for abdominal surgery is incorporated.

Exo- and endoscopes with video recording

A 3D video camera (exoscope) attached to the endoscope can be used as an exoscope with a short arm, and may therefore replace the operation microscope introducing videosurgery acting as a microscope. Several 3D endoscope systems are available. Fish eye endoscopes without distortions have been developed. Endoscopes are used either as such or as viewing instruments, where the operation takes place in the field of vision beside the endoscope, instead of through it.

3D video camera and Head Mounted Display (HMD)

The microscope may be replaced by a 3D video camera and Head Mounted Display (HMD). Instead of having a space occupying microscope in the operation room a little 3D video camera is placed over the surgical area. The video image is transmitted to a HMD worn by surgeons, nurses, students and even other consultants in their offices. With a HMD the image is perceived as truly 3 dimensional and with a size corresponding to a 20" TV monitor at arms length. The HMD is also coupled to an endoscope, so the surgeon can choose between the images presented to him/her either as a full screen image from the video camera (exoscope) or the image from the endoscope inside of

the patient in the surgical area. In the HMD picture in picture (PIP) can be presented. This also includes MRIs and real time ultrasound images, so the surgeon can choose between having one image, two images, three images or even four images at the same time presented in the HMD from the different modalities he/she has chosen to use at the specific surgical procedure.

The surgeons do not necessarily have to operate through the endoscopes, but may use them only as viewing instruments. This facilitates the surgical procedure. Using video cameras in surgery provides the whole surgical area to be focused and not, as it is today, using the microscope where just a part of the area is focused. The zoom on the camera will provide the desired magnification.

Voice recording

The surgeons and nurses wear headsets for voice recording to the "black box" for documentation and teaching purposes.

Neuronavigation

A neuronavigation system is incorporated. MRS's (functional or plain MRI's) and CT images are imported from the radiological department or via the Net, using DICOM or from CD's.

Video-guided Ultrasound Imaging Systems

Video and ultrasound (US) serve as a continous real time 3D intraoperative tool for image-guided procedures, when the target has been found by the aid of the neuronavigational system. In combination with preoperative CT/MR surface and landmark recognition, it matches the data and give a precise real-time image throughout the procedure by performing real-time volume rendering. The subunit can be either conven-

tional US, 3D US or colour Doppler US for localization of vessels. The image processing will all be digitized for merging images. The probes are available in various sizes, from less than 1 mm to several cm in diameter. They can be used through the working channels of the endoscopes and can either scan horizontally or straightforward at 0° or at 90°. They can be placed in the craniotomy or in a separate craniectomy. The new concept for the US will give the possibility of postoperative US control in the ICU, the ward and Open Patient Department (OPD).

Cytoscanner

The cytoscanner provides real-time images of the tissue microcirculation. The cerebral blood flow (CBF) may also be demonstrated real-time during surgery using real time laser-Doppler perfusion imaging (LDPI).

Surgical Ultrasonic Aspirator

The Surgical Ultrasonic Aspirator for tumor removal. (Cavitrone, CUSA, Dissectron). Many surgeons prefer to use an ultrasound aspirator for tumor removal, instead of laser or electrocautery.

Laser source

Exchangeable laser subunits will come in the powers 15W, 30W and 60W. There will be a complete range of contact and non-contact probes, as well as endoscopically compatible fibers.

A video console 2 with 3D images on a swing arm 3.

This is one high definition video screen 2, divided into four sections. This is placed on a swing 3 arm, mounted on the workstation 1. The arm 3 can swing out from the workstation 1 to place the screen

2 above the patient, in front of the surgeon. There will be two sections for viewing from the endoscopes: one from the 3D video camera (exoscope) controlling the endoscope and one for the endoscope. Another section is for the neuronavigation system with visible real time movements of the instruments inside the operating field superimposed over a 3D non-real-time MRI image. The last screen is for the intraoperative ultrasound image. One of the sections can be changed at any time to fluoroscopy imaging or to real time CT/MR. All four images are transmissible for instant telemedical advice either within the same country or abroad. For the surgeon the Vista-Video System and/or the Virtual Retina Display system will be incorporated.

ReachIn Display (RID).

To augment reality, the workstation may be connected to a ReachIn display where virtual images are reflected in glass that the physical patient can be seen through.

Operating panel on the workstation.

On the workstation 1 there is an operating panel 5, preferably turned away from the surgeon at an oblique angle. This panel has four screen sections 11, 12, 13, 14, and a keyboard that is easy for an assistant to view and operate. Photo equipment is placed in the panel to produce a Polaroid instant colour photograph of the four screen sections 11, 12, 13, 14. The keyboard comprises the commands and settings of all the subunits 6a-6h. A speech synthesis board will be incorporated for a hybrid voice-and hand control. The user interface will be like a PC's, with a start button, icons, folders and files, intuitive and easy to understand and to use.

Having a standard user interface greatly improves the usefulness of the workstation partly because it allows the user to become more acquainted with it, partly because it allows similar layouts for the controls of the various modules 6a-6h incorporated in the workstation 1.

Flexible arms carrying the endoscope, the video camera, the ultrasound probe, the laser probes, and forceps

The arms 7 are flexible, with semi-rigid, chrome-plated, laser-protected shanks. Each arm is connected to a working instrument: endoscope, laser, ultrasound, ultrasonic aspirator, electrocautery (mono- and bipolar coagulation and cutting), video camera, irrigation or suction. The arms, collectively called the octopus 8, can be held stable in any desired position.

Modular

All subunits 6a-6h are modular. Standardized adapter system lets each company adjust its equipment to the workstation 1. Surgeons can thus choose individually between available lasers, ultrasound and endoscopes, etc. The subunit's adapters are identical and the subunits are exchangeable, so those special requirements for each individual surgeon can be met according to the type of operation to be performed. The subunits 6a-6h can be quickly and easily exchanged for maintenance or updating according to the technological advances in each field of surgery.

Moreover it allows the hospital to start with a basic workstation 1 with a minimum of modules 6a-6h, and then subsequently extend the range of modules 6a-6h with new modules 6a-6h, as they are needed or as finances allow them to be purchased. Leasing may also be an option.

Since the modules 6a-6h are exchangeable the workstation 1 may easily be reconfigured for specific operations. In particular, if the hospital is in possession of several workstations 1, infrequently used specialized modules 6a-6h may be switched around between several workstations 1. It is thus not necessary to have such a specialized module 6a-6h for each of the workstations 1, which reduces the expenses.

As can be seen from fig. 2, the modules 6a-6h are adapted to be located in appropriate, preferably equally sized, slots 9 in the workstation 1. The modules 6a-6h may be inserted into any one of these slots 9 thereby making connection with standardized bus and device interface system.

Centralized internal control

When inserted in the slots 9, the modules 6a-6h are controlled by a comprised central controlling unit (CCU) configured to control and/or supervise the functionality of medical units or modules 6a-6h of the workstation 1.

The modules are in data communication with the central controlling unit. The data communication between the modules 6a-6h and the central controlling unit takes place within the housing of the surgical workstation 1.

There is provided a standardized bus and device interface system within the workstation 1 allowing the modules 6a-6h to be fully exchangeable.

Using a standardized device interface and bus system allows easy user control from the standardized graphical user interface. Furthermore the same functionality of different modules 6a-6h, e.g. such as switch-on, scaling of output values, may be controlled centrally, thus obviating the need for specific switches or dials on each and everyone of the different modules 6a-6h.

Miscellaneous

A music cassette and CD for the patient in case of local anaesthesia, and for the operating team. In the workstation 1, where the subunits 6a-6h are housed, there are a cooling system and a noise and vibration reduction system. The heat produced is directed to a warming blanket covering the patient. Intraoperative CT will be possible with a separate gantry.

Telemedicine

Videoconference over the Internet during surgery. Telesurgery over a distance or remote surgery within the same OR.

The Black Box

For teaching and documentation. All information will during surgery be time-stamped and recorded for future documentation: Video from the neuronavigation, CT, MRI and surgical procedures; Voice from the surgeon and nurses during surgery; Neuromonitoring and cardiovascular data from the patient instrumentation; Anaesthesia.

Teleservicing

The subunit will be self-repairing, with two back-up systems. It will have instant satellite servicing.

The unique combination of some or all of the above-mentioned items in one handy wheeled workstation 1 reduces resource requirements by combining and partially integrating the functionality of the subunits, such as a single source for power, light, coagulation, cutting, irrigation, etc. The main, basic combination is the electrocautery, ultrasound,

suction, irrigation, 3D exo- and endoscopes, together with the videoscreen 2 on the swing arm 3. The video and voice recording, in combination with the database, is indispensable for documentation. The real time 3D display of the route of the gliding path for the endoscope and operating instruments through the brain during surgery is essential in neurosurgery.

The workstation 1 is on wheels 4 fixed on a suspension device, easily moved over doorsteps. The electrical supply to the workstation 1 is an automatic switch mode power supply.

A Virtual Visualization and Navigation System (VIVIAN) from KRDL, Singapore may also be a part of the workstation. The VIVIAN integrates four components: A brain atlas registered with the patient's data, geometric models of stereotactic frames and any other localization and guidance device, a ReachIn computer display, and neurosurgery tools. VIVIAN will clear the surgeons's mental picture of the structures in space. This will enhance the visiospatial ability that correlates with a higher level of surgical skills.

The following advantages are obtained by the present invention:

A. *For the patient:* Minimum surgery, small scars, shorter anaesthesia, less postoperative discomfort and pain, less blood transfusion, less risk of infection, as well as shorter hospitaslisation time, recovery, and rehabilitation, which all imply lower cost.

B. *For the surgeon:* More comfortable working positions, better viewing. Ergonomic working position for the surgeon, increasing the safety for the patient. Diminished bleeding, access to inoperable tumors for biopsies and removal. Increased numbers of operations, and a faster cleaning process in preparation for the next patient. The workstation 1 can be

moved from one operating room to another, and increases the rationalization of the working process.

C. *For the hospital:* Cost-effective by diminishing hospitalisation days, such as sutting craniotomies from 8 to 3 days, and less use of expensive ICU beds. More patients through the system, cutting waiting lists. The workstation can be used by many specialties, so a hospital needs only one workstation, at least initially. It will be cheaper to buy one workstation than an equivalent set of equipment separately. It can be coupled to telemedicine, which in many hospitals will increase the range of surgical procedures. Patients will choose hospitals that have the equipment for surgery leading to the least postoperative discomfort.

D. *For the staff:* Easy and quick to prepare for surgery. Easy to clean. Less open blood loss in the operating rooms. Time saving.

E. *For governments:* Less hospital expenses to be paid by state-funded systems.

F. *For the environment:* Better and more intense use of resources, with minimal waste of hospital equipment.

PATENT CLAIMS

1. A mobile surgical workstation comprising a housing adapted for accommodating medical subunits, characterized in that the surgical workstation is adapted for accommodating exchangeable modular subunits.

2. A mobile surgical workstation according to claim 1, characterized in that it comprises a central controlling unit and interface means allowing the central controlling unit to communicate with any modular subunit accommodated in the workstation.

3. A mobile surgical workstation according to claim 2, characterized in that said communication between the central controlling unit and the subunit takes place within the housing of the surgical workstation.

4. A mobile surgical workstation according to any one of the preceding claims, further comprising an applicator arm having a first end pivotally and tiltably connected to the workstation, said application arm comprises at a second end the connections or further connections, such as plugs, to medical applicators, said connections being in data communications with medical subunits of the workstation.

5. A surgical workstation according to any of the preceding claims, further comprising a central power supply supplying power to subunit(s) of the workstation.

6. A surgical workstation according to any of preceding claims, further comprising at least one monitor configured to display information supplied by one or more subunits of the workstation.

7. A surgical workstation according to claim 6, wherein said monitor(s) being arranged in relation to the workstation in such a manner that the information

can be presented in front of a surgeon during operation.

8. A surgical workstation according to claim 6 or 7, wherein said monitor(s) being high definition video screen(s), divided into sections, preferably divided into four section, and wherein the monitor(s) being arranged on a swing arm mounted on the workstation.

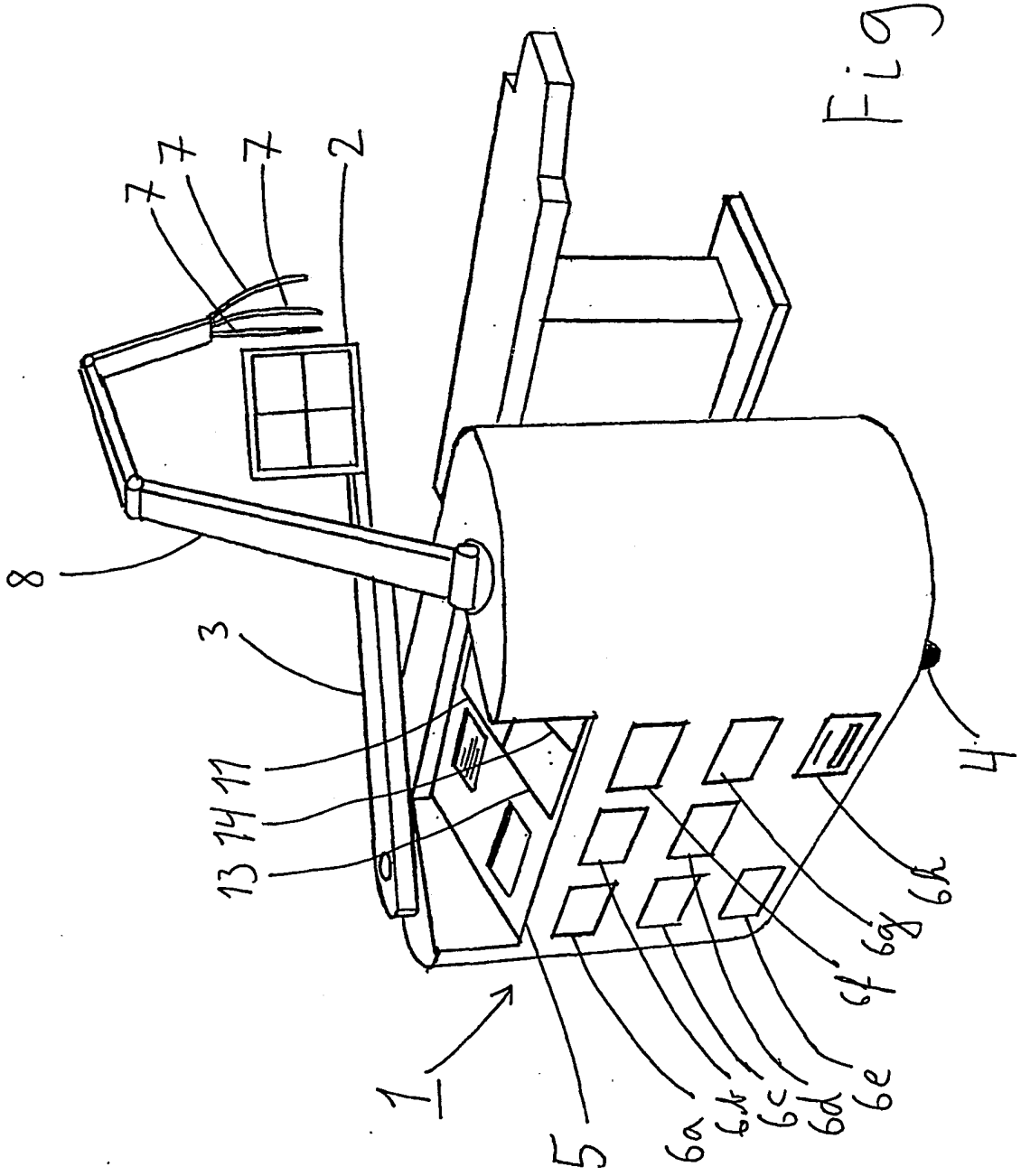
9. A surgical workstation according to any of the preceding claims, wherein the workstation is configured to communicate data between medical units of the workstation and data equipment not being included in the workstation.

10. A surgical workstation according to claim 9, wherein the configuration to communicate data is a data connection between the central controlling unit and a data network, such as an intranet, an internet or the like.

11. A mobile surgical workstation according to any one of the preceding claims c h a r a c t e r i z e d in that the workstation is mounted on wheels.

12. An operating room comprising a surgical workstation according to any of the preceding claims.

Fig. 1



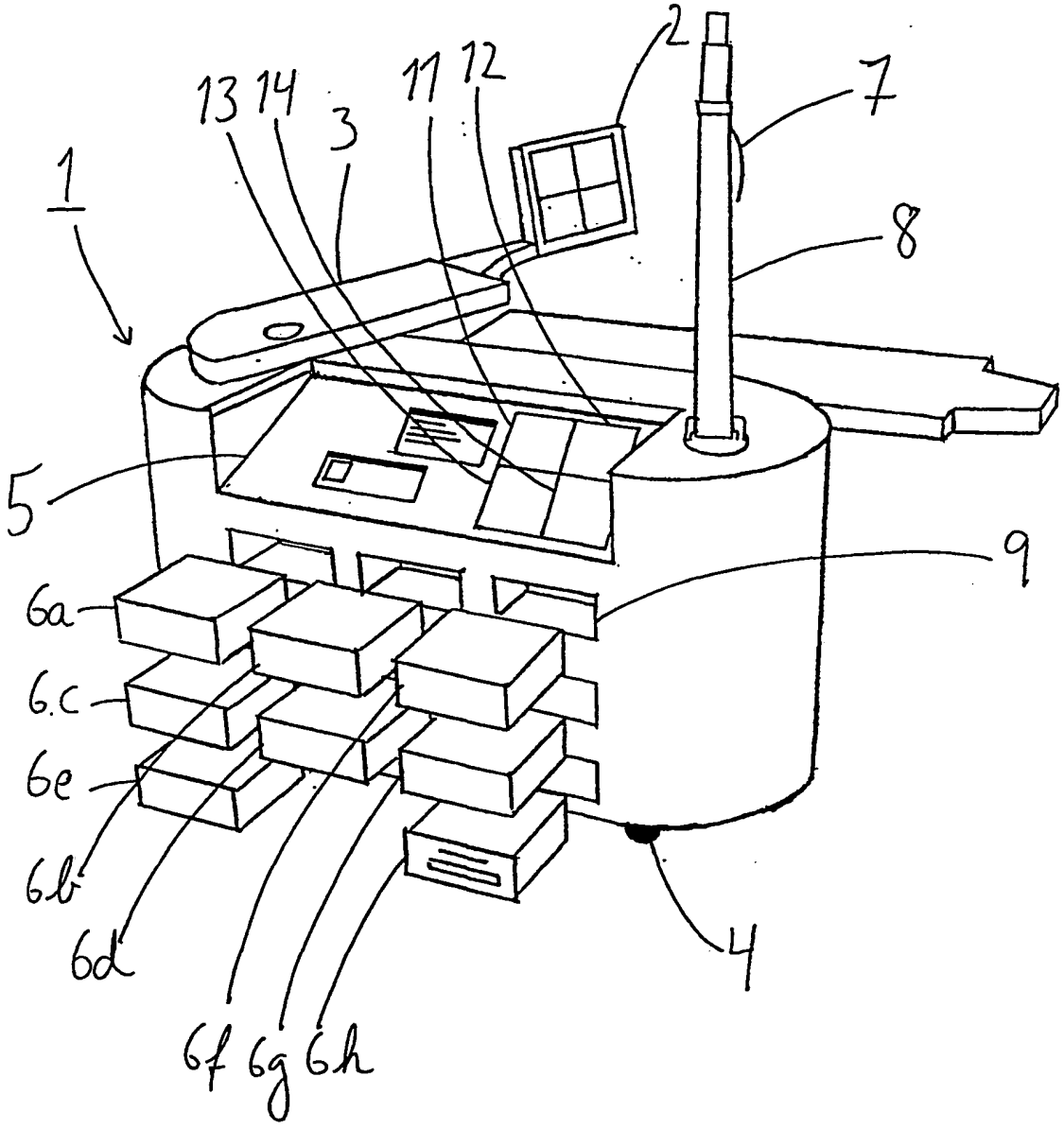


Fig. 2